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Inventory of the gene pool garden of the Sheki Regional Scientific Center of ANAS: Assessment of structure, species, biodiversity, and agro-biodiversity

Farhad Azizov[1*], Aygun Ismayilova[2], Aygun Babazade[1], Mubariz Pashayev[1]

[1] *Department of Plant Biodiversity and Gene Pool, Sheki Regional Scientific Center, Azerbaijan National Academy of Sciences, 24 L.Abdullayev Str., AZ5500, Sheki, Azerbaijan*
[2] *Department of Ecological Geography, Sheki Regional Scientific Center, Azerbaijan National Academy of Sciences, 24 L.Abdullayev Str., AZ5500, Sheki, Azerbaijan*

[*] ***For correspondence:*** *azbioflor@rambler.ru*

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This study investigates the agro-biodiversity of fruit and berry plant species developed through folk selection in northwestern Azerbaijan (in the regions of Balakan, Zagatala, Qakh, Sheki, Oghuz, and Gabala). A comprehensive assessment was conducted at the Gene Pool Garden of the Sheki Regional Scientific Center of the Azerbaijan National Academy of Sciences, based on materials and data covering the years 1975–2025. The inventory systematically evaluated the biomorphological, ecophysiological, and phenological characteristics of folk-selected varieties. The primary objectives of the study are to conserve genetic resources, identify donor materials for future breeding programs, and establish a scientific basis for sustainable agricultural development. Analyses of the α- and γ-diversity indicators of the inventoried biodiversity revealed the taxonomic structure of the gene pool and the ecological-synotic composition of the flora. The results demonstrate that the region possesses rich genetic resources of strategic importance for sustainable agriculture, food security, and plant breeding initiatives. The studied fruit and berry species exhibit significant potential for nutritional and pharmaceutical applications. These findings will contribute substantially to the conservation of national gene pools, aligning with the priorities of international organizations such as the Food and Agriculture Organization of the United Nations (FAO) and the Convention on Biological Diversity (CBD).

Keywords: *Gene pool, agro-biodiversity, inventory, taxonomic structure, ecological-synotic classification, α- and γ-diversity, evaluation*

INTRODUCTION

In the 21st-century global scientific and socioeconomic agenda, the conservation of biodiversity, the sustainability of agricultural gene pools and the preservation of local agricultural traditions are key topics. As emphasised in the FAO report The State of the World's Biodiversity for Food and Agriculture, biodiversity for food and agriculture (BFA) is rooted in genetic, species and ecosystem diversity, and is essential for ensuring food security, nutrition and sustainable agriculture. The report emphasises the importance of conserving agricultural gene pools and studying and preserving local varieties (folk selection — landrace) as a global scientific and methodological foundation (Chernov, 1991).

The Kunming-Montreal Global Biodiversity Framework (GBF), adopted internationally, establishes ambitious targets for the conservation, restoration and sustainable use of biodiversity by 2030. This framework also encompasses the conservation of agrobiodiversity and stimulates specific national-level actions regarding the maintenance of gene pools (Stephens, 2023). The GBF and its guidelines are key documents in shaping national and regional policies.

The northwestern region of Azerbaijan -

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comprising the districts of Balakan, Zagatala, Gakh, Sheki, Oguz and Gabala — differs markedly from other parts of the country in terms of climate and topography, providing favourable conditions for diverse agroecosystems. These districts are located within the Sheki-Zagatala economic region and include various elevation zones. The combination of submontane and foothill areas facilitates the formation of microclimates. Consequently, there is high genetic diversity among local stone fruit, pome fruit, rose and berry plant varieties and species. The region's overall climate is characterised by relatively humid and mild-to-warm conditions. For example, Zagatala and Gabala have recorded significant precipitation levels and Köppen Cfa-type climate indicators, while Sheki exhibits temperature variability typical of mountainous climates (Mustafabeyli, 2023). These features expand the adaptive range of local varieties and provide valuable traits for breeding and selection.

Long-term reconnaissance and genetic-technological studies conducted at the Sheki Regional Scientific Centre of the National Academy of Sciences of Azerbaijan (ANAS) from 1975 to 2025 have aimed to systematically investigate the biomorphological, ecological-senotic, and agroecological characteristics of local landrace varieties. These studies aim to systematise the collected samples of local varieties, establish and preserve gene pool databases, and create a foundation for future breeding work. Inventorying landrace varieties is strategically important for preserving genetic diversity, ensuring the sustainable development of agriculture and local food security, and maintaining cultural-agricultural traditions — an approach that aligns with the global priorities of the FAO and the CBD. (FAO, 2019; Azizov, 2020).

One effective mechanism for conserving gene pools is establishing gene bank orchards and *in situ* and *ex situ* collections, based on adapting specimens to local ecological and climatic conditions (Ramirez-Villegas et al., 2022). This approach preserves genetic diversity and facilitates the use of local varieties in cultivation practices and breeding programmes. Systematic analysis of long-term reconnaissance results in the region enables the identification of the ecological and senotic differences of local varieties and their agroecological suitability, facilitating the selection of promising materials for breeding. These studies enrich the academic knowledge base and provide practical contributions to national and regional agricultural policies.

Based on scientific research conducted between 1975 and 2025, the main objective of the current study is to comprehensively analyse the biomorphological and ecosenotic characteristics of locally collected fruit and berry varieties in the Shaki-Zaqatala region. The study aims to determine agrobiodiversity indicators for each variety and develop scientific foundations for optimising existing gene bank orchards. This work aligns with national strategies for the conservation of biological diversity, including the Global Biodiversity Framework (GBF) targets of the Convention on Biological Diversity (CBD), and with the principles of sustainable management of food and agricultural biodiversity emphasised by the Food and Agriculture Organization of the United Nations (FAO) (Convention on Biological Diversity (CBD), 2022).

The scientific and practical significance of the study is summarized in the following aspects:

(I) The scientific description of the biomorphological, phenological, and ecological traits of local traditional varieties — providing a necessary database for the characterization of genetic resources;

(II) Preservation of genetic diversity through the implementation of in situ and ex situ conservation strategies in gene bank orchards;

(III) Utilization of the obtained data in breeding programs, sustainable agricultural development, and strengthening local food security;

(IV) Providing a scientific basis for the formulation of national and regional policies in accordance with international conventions and FAO recommendations (FAO, 2019);

(V) Ensuring the population has access to high-quality, ecologically safe agricultural products and contributing to the improvement of employment levels.

In line with the national development priorities set out in the “Azerbaijan–2030: Vision to the Future” Development Concept, the sustainable management of ecosystems, the conservation of biodiversity and the rational use of natural resources have been identified as key strategic areas. (“Azerbaijan 2030...”, 2021). In this context, the creation of a dynamic database of information and experts characterising the flora and vegetation diversity that define the rich ecological and natural environment of the Shaki–Zagatala region is recommended as an important scientific and practical objective. Such a database would enable deeper scientific analysis of the region’s ecosystems and provide a solid foundation for biodiversity conservation and management decisions.

The sustainable use, effective conservation and management of the biodiversity of stone fruit, pome fruit and nut-bearing plants, which are widely distributed across the region, is particularly important at the ecosystem level. To this end, collecting wild, cultivated and folk-selected varieties and preserving them through vegetative propagation methods (such as cuttings and budding) is considered a significant scientific and practical necessity.

Although various folk selection varieties have been included in the State Register of the Republic of Azerbaijan, fundamental scientific research into existing genetic resources, particularly the systematic study of the ecological and genetic aspects of biodiversity, has not yet been conducted on a sufficiently broad scale. A comprehensive investigation of the existing plant gene pool is therefore necessary, as well as an assessment of their genetic and adaptive potential, to identify future possibilities for breeding, introduction, and agrobiotechnological applications (Asadulaev et al.,2021).

The Gene Pool Garden of the Shaki Regional Scientific Center(RSC) of the Azerbaijan National Academy of Sciences (ANAS), established in 1975, is a particularly significant research facility in this field. The main objectives of the present research are the comprehensive study of the dendrological collection materials preserved in the Gene Pool Garden and the identification of the region’s taxonomic, ecological-coenotic and biodiversity indicators. The studies conducted for this purpose aim to contribute to the scientific systematisation of local genetic resources and the development of strategies for the sustainable management of ecosystems.

MATERIALS AND METHODS

The current state of the Gene Pool orchard was inventoried and its biodiversity assessed. The orchard was established in a 6.0-hectare area at the Sheki Regional Scientific Center of ANAS in 1975 and is based on folk selection varieties of pome and stone fruit plants collected from the high mountain villages of the region.

Geobotanical and ecological-geographical studies were conducted based on the 'step-by-step' principle and the route method (Dospekhov, 1985). The precise coordinates of the area and existing orchards were determined using GPS and GIS technologies. Taxonomic structure and phylogenetic classification were conducted in accordance with the APG III (2009) and APG IV (2016) systems. This approach enabled the ecological-cenotic composition of the flora to be identified more accurately (Mammadov, 2018).

Based on the results, structural biodiversity was analyzed. To assess species biodiversity in geobotanical plots, the following indices were determined:

Species richness – the total number of species present in the area;

Species density – the number of species per unit area (Hulbert, 1971; Whittaker, 1977).

This approach ensured a systematic analysis of the ecological and phylogenetic characteristics, as well as the biodiversity, of high-mountain fruit plant flora in the Shaki region.

ANALYSIS OF THE STUDY

In accordance with the objectives of the study, in the initial phase, geobotanical plots were systematically designated in the Genopool orchard to determine the structure and distribution of existing plant species. The area of each plot was measured accurately, fruit species were categorized and recorded in detail, and their distribution was documented. Based on the collected data, a map-scheme reflecting the topographic and vegetation characteristics of the orchard was prepared (Fig. 1).

As can be seen from the map-scheme, the Gene Pool Garden has a relatively simple structure and comprises plots I–X, which are organized according to individual taxonomic units. There is also an additional XI geobotanical plot, which consists of mixed taxa.

To accurately determine the structural biodiversity of the Gene Pool Garden, geobotanical and ecogeographical studies were initially conducted. The taxonomic structure and ecological composition of the flora are presented systematically in Table 1.

Table 1 illustrates the taxonomic structure of the Gene Pool Garden, showing the total number of plants by families, genera, and species. This information provides a solid basis for assessing biodiversity and for the conservation of gene pool resources.

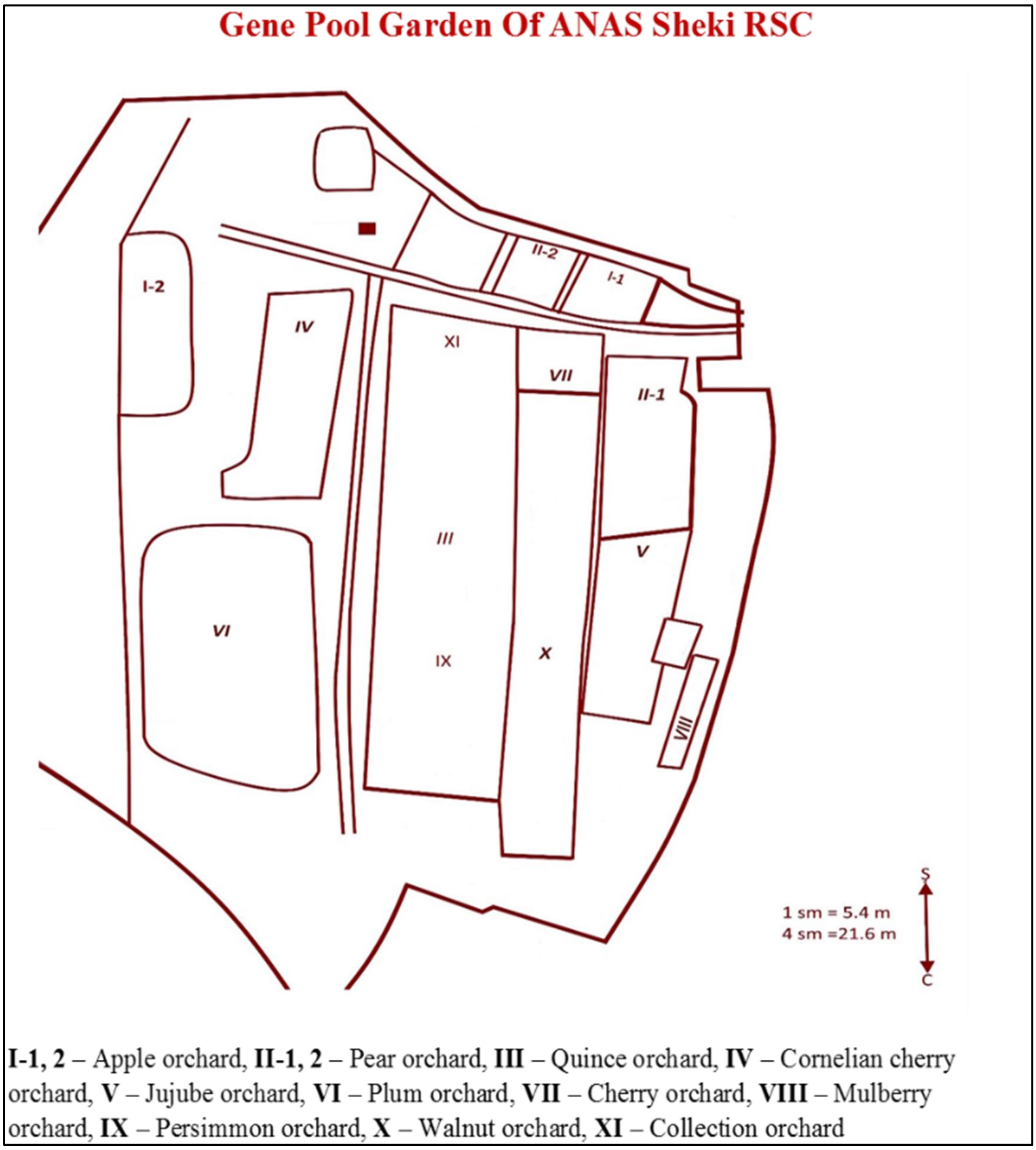

Fig. 1. Map-scheme of the Geno pool Garden of the Sheki RSC of ANAS (DSH - 743,62 **N**41°13'27'', **E**47°10'28''E).

Table 1. Taxonomic Structure of the Gene Pool Garden

№	Family (Botanical family name)	Genus (Common name)	Number of species studied	Total number of specimens
1.	Rosaceae Juss (Rose family)	*Crataegus tourn.ex* L. (Hawthorn)	2	30
		Cydonia Mill (Quince)	14	277
		Malus Mill (Apple)	35	83
		Prunus Mill (Plum)	10	30
		Pyracantha M.Roem (Firethorn)	1	1
		Pyrus L. (Pear)	37	86
		Rosa L. (Dog rose)	1	6
		Prunus avium (L.) L. (Sweet cherry)	2	24
2.	Cornaceae Dumort. *(Dogwood family)*	*Cornus* L. (Dogwood)	9	45
3.	Juglandaceae A. Rich. ex Kunth *(Walnut family)*	*Juglans* L. (Walnut)	1	39
4.	Moraceae Gaudich. *(Mulberry family)*	*Morus* L. (Mulberry)	2	124
5.	Viburnaceae Raf. *(Viburnum family)*	*Viburnum* L. (Viburnum)	1	6
6.	Elaeagnaceae Juss. *(Oleaster family)*	*Hippophae L.* (Sea buckthorn)	2	15
		Elaeagnus L. (Oleaster)	1	6
7.	Anacardiaceae Lindl. *(Sumac family)*	*Rhus* L. (Sumac)	2	7
8.	Rhamnaceae Juss. *(Buckthorn family)*	*Ziziphus jujuba* Mill. (Jujube)	1	1
9.	Lamiaceae Martinov *(Mint family)*	*Salvia rosmarinus* Spenn. (Rosemary)	1	1
10.	*Ebenaceae Gürke* (*Persimmon family*)	*Diospyros* L. (Persimmon)	2	23
11.	Berberidaceae Juss. *(Barberry family)*	*Berberis* L. (Barberry)	1	3
Total	**11 families**	**19 genera**	**124 species**	**807 specimens**

As shown in the table, the plants in the Genopool Garden are present across 11 geobotanical plots. The dendroflora is highly diverse, with the taxonomic structure predominantly represented by plants belonging to the *Rosaceae* L. family. Within this family, the genetic pool includes 537 individuals across 102 species from 8 genera, while the remaining 10 families comprise 270 individuals across 23 species from 11 genera.

The studied Genopool Garden consists of 11 geobotanical plots and belongs to the category of protected associations. Among these plots, the 10th plot (Walnut) has the fewest plant specimens and species, whereas the III plot (Quince) contains the highest number of plants. Table 1 presents the number of plants in the respective geobotanical plots according to family, genus, and species. The results of the study indicate that the Genopool Garden is floristically diverse and taxonomically rich. In terms of species abundance, the family *Rosaceae* Juss. occupies the leading position within the dendrocollection. Specifically, the collection includes 86 pear accessions belonging to 37 species of the genus *Pyrus* L.; 83 apple accessions representing 35 species of the genus *Malus* Mill.; 277 quince accessions belonging to 14 species of the genus *Cydonia* Mill.; 30 plum and cherry-plum accessions belonging to 10 species of the genus *Prunus* Mill.; 24 cherry accessions belonging to 2 species of the genus *Padus* Mill.; 6 dog-rose accessions belonging to 2 species of the genus *Rosa* L.; and 30 hawthorn accessions belonging to 2 species of the genus *Crataegus* Tourn. ex L.

Other recorded families include *Cornaceae* Bercht. & J. Presl, represented by 45 cornelian cherry accessions belonging to 9 species of the genus *Cornus* L.; *Juglandaceae* DC. ex Perleb, with 39 common walnut (*Juglans regia* L.) accessions belonging to the genus *Juglans* L.; Moraceae Gaudich., with 124 mulberry accessions representing 2 species of the genus *Morus* L.; and *Ebenaceae* L., with 23 persimmon accessions belonging to 2 species of the genus *Diospyros* L.

Additional families represented in the collection include Caprifoliaceae Juss., with 6 viburnum accessions of the genus *Viburnum* L.; *Elaeagnaceae* Juss., with 6 sea buckthorn accessions *(Hippophae rhamnoides* L.) and 15 oleaster accessions of 2 species of the genus *Elaeagnus* L.; *Anacardiaceae* Lindl., with 7 sumac accessions belonging to the genus *Rhus* L.; *Rhamnaceae* Juss., with 1 jujube accession (*Ziziphus jujuba* Mill.); Lamiaceae Martinov, with

1 rosemary accession (*Rosmarinus officinalis* L.); and *Berberidaceae* Juss., with 3 common barberry accessions *(Berberis vulgaris* L.) belonging to the genus *Berberis* L.

In summary, the dendrocollection at the Genepool Garden comprises 23 species belonging to 11 genera across 10 families, in addition to the Rosaceae family. This totals 270 plant specimens.

Separate geobotanical plots were measured to assess the biodiversity of species in accordance with the taxonomic structure of the genepool garden. The number of species and individuals per species was determined and presented in Table 2.

Table 2 provides information on the taxa corresponding to different genera within eobotanical plots I–X. Plot XI, the Collection Garden, consists of mixed taxa and includes data on various genera and species.

Bio-research conducted throughout the season indicates that the status of taxa in each geobotanical plot are in a normal state, with regular rehabilitation measures being implemented. The taxonomic structure of the Geno Pool Garden is used to evaluate species diversity in plant communities across geobotanical plots.

Table 2. Taxonomic structure of the genepool garden and evaluative indicators of species diversity across geobotanical areas.

№	**Geobotanical Areas**	**Area Size (m^2)**	**Number of species**	**Individuals per species**
I	Apple	1384	35	83
II	Pear	2745	37	86
III	Quince	4445	14	277
IV	Cornelian Cherry	735	9	45
V	Hawthorn	820	2	30
VI	Plum	3920	10	30
VII	Cherry	574	2	24
VIII	Mulberry	1050	2	124
IX	Persimmon	352	2	23
X	Walnut	2100	1	39
XI	Collection Garden	532	10	46
Total	**11 Garden**	**18.657**	**124**	**807**

To assess the diversity of plant species in the Genopool Garden, the taxonomic composition of the flora in its geobotanical zones was recorded based on the data presented in Table 2. Based on the obtained results, the α and γ diversity indices were determined (Table 3). The geobotanical zones were conditionally designated by the letters A, B, C, D, E, F, J, K, L, M, and N (Smirnov, 2014).

The highest species density in geobotanical plots was observed in K-11.8, N-8.64, L-6.53, C-6.23, D-6.12, A-5.99, and J-4.18 plots. In terms of species richness, the highest values were recorded in B-37, A-35, C-14, N-10, F-10, and D-9 plots. In other plots, this indicator ranged from 1 to 10 (Table 3).

Table 3. Inventory Biodiversity Indicators of the Shaki RSC Gene Pool Garden.

№	**Ecological-synotic groups**	**Number of individuals**	**Species density (per 100 m^2) α**	**Species richness**
1.	A	83	5.99	35
2.	B	86	3.13	37
3.	C	277	6.23	14
4.	D	45	6.12	9
5.	E	30	3.65	2
6.	F	30	0.76	10
7.	J	24	4.18	2
8.	K	124	11.8	2
9.	L	23	6.53	2
10.	M	39	1.85	1
11.	N	46	8.64	10

The calculations show that the species density across the geobotanical areas varies within the range of 0.76–11.8. The highest value was recorded in the 8th geobotanical area (11.8), while the lowest was observed in the 6th geobotanical area (0.76) (Fig. 1). Thus, the results indicate that the Genepool Garden is rich in both structural and species diversity, belonging to the mixed-type association group. The flora of the Gene Pool Garden demonstrates considerable diversity at the plot level and is characterised by its richness and variability. The plants preserved in the collection within each geobotanical plot are considered valuable from nutritional and pharmaceutical perspectives, according to taxonomic units. Across 11 geobotanical plots, species richness ranged from 1 to 37; the lowest richness was observed in walnut species, while the highest was recorded in pear species (Fig. 2).

Furthermore, to determine the biodiversity of species in the Genepool Garden, the results of the phytocoenotic assessment (i.e., species richness and density) for each geobotanical plot were presented in a diagram (Fig. 2 and 3) (Magurran, 1992).

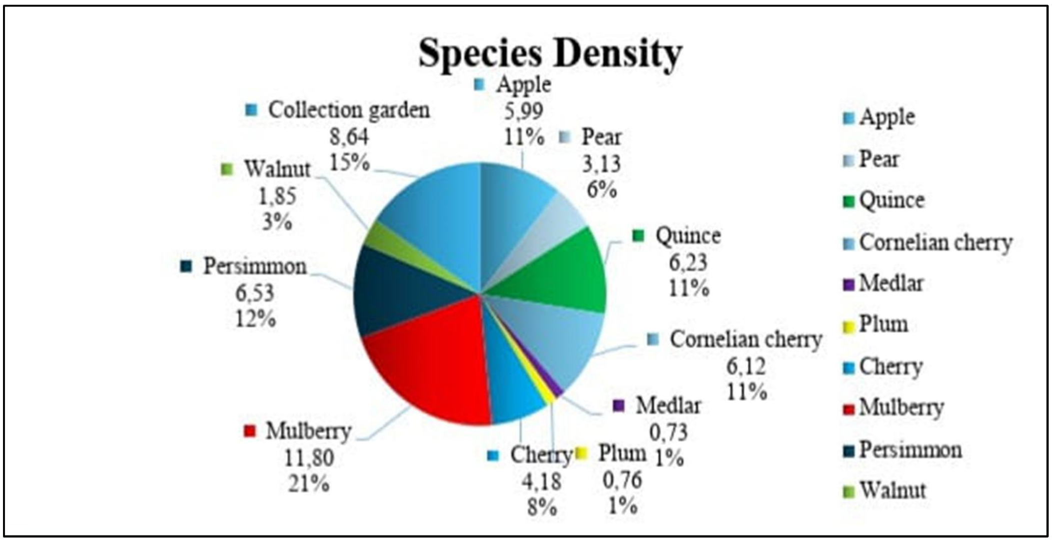

Fig. 2. Structural distribution of fruit species density in the Genepool Garden of Sheki RSC.

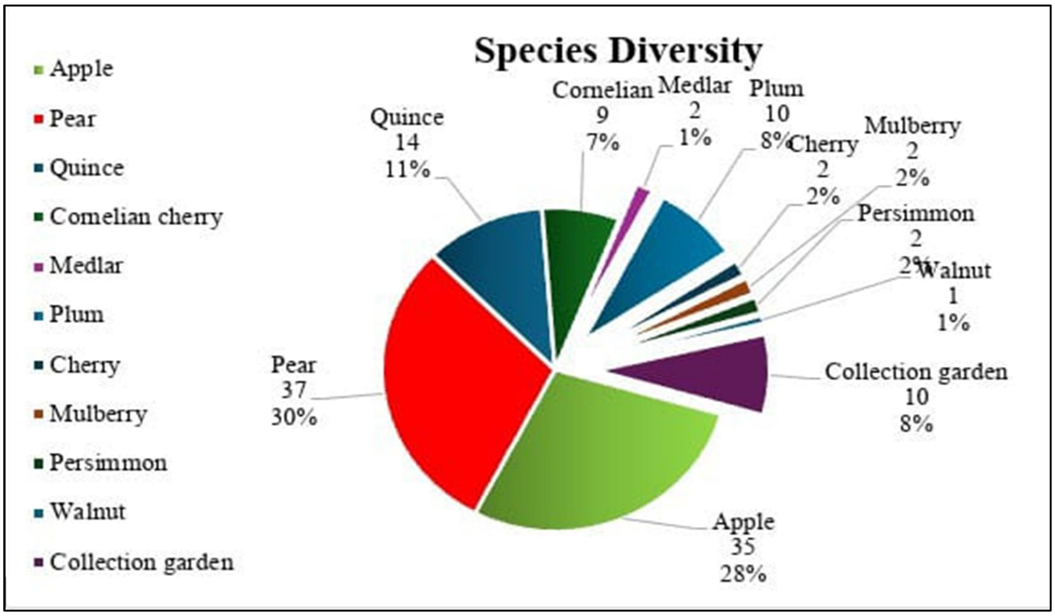

Fig. 3. Structural indicators of fruit species diversity in the Genepool Garden of Sheki RSC.

RESULTS AND DISCUSSION

The Gene Pool Garden is of significant scientific and practical importance in terms of agro-biodiversity. The dendrological collection consists mainly of fruit, stone fruit and nut-bearing plant species collected from the region's high mountain villages. These cultivars have adapted to the local soil and climatic conditions and are highly productive. Their ecological resilience, high biochemical indicators and genetic stability make these cultivars valuable for technical purposes and as reliable planting material for developing fruit cultivation and establishing new intensive orchards in the region. These characteristics highlight the essential role of the Gene Pool Garden in the conservation, restoration, and sustainable use of regional agro-biodiversity.

The area encompasses species that are important for the food and pharmaceutical industries, as well as tree and shrub species that are valuable for technical applications, environmental control and forest restoration activities. This diversity reflects the Gene Pool Garden's functional and ecological richness.

A significant proportion of the medicinal and other useful plant species preserved in the Gene Pool Garden (12 species) are listed in Azerbaijan's Red Data Book. This confirms that, from a conservation perspective, the Gene Pool Garden represents a highly valuable and biologically diverse plant community.

In addition to the dendrological collection, the Gene Pool Garden also features technical, food and industrially valuable nectar-bearing plants that were originally found in the area, but were not included in the dendrological collection.

The plant species included in the II and III editions of the Red Book of Azerbaijan have been identified based on the following taxa:

1. Pomegranate – *Punica granatum* L.
2. Sweet chestnut – *Castanea sativa* Mill.
3. Rosa azerbaidzhanica – *Genus Rosa* L.
4. Persian ironwood – *Parrotia persica* (DC.) C.A.Mey.
5. Cherry laurel – *Prunus laurocerasus* L.
6. Dusky Whitebeam – *Sorbus subfusca* Boiss.
7. Hyrcanian poplar – *Populus hyrcana* Grossh.
8. Pontic hawthorn – *Crataegus pontica* K. Koch
9. Willow-leaved pear – *Pyrus salicifolia* Pall.
10. Chestnut-leaved oak – *Quercus castaneifolia* C.A.Mey.
11. Caucasian persimmon – *Diospyros lotus* L. (II edition)
12. Cotoneaster – *Cotoneaster* Med.

The research revealed that the tree and shrub species preserved in the dendrocollection and in other areas of the Gene Pool Garden at the Sheki Regional Scientific Centre are the main components of the region’s natural ecosystem. These species are well adapted to local ecological conditions, have high adaptive potential, and play a crucial role in conserving the regional gene pool. (Vasilevich, 1992; Jogman, 1999).

Furthermore, the research findings indicate that the plant species collected in the Gene Pool Garden are important not only for conserving ecosystem biodiversity, but also for their economic and social value. These species have substantial potential for restoring forest ecosystems, rehabilitating degraded soils and landscapes, and developing fruit growing — a priority area for the region's agricultural sector. This potential is also vital for establishing new orchards, providing the population with clean, ecological fruit products and increasing employment levels in rural areas.

Studies of the structural and species diversity of the Gene Pool Garden show that it is mainly made up of relict and endemic species. These taxa play a significant role in maintaining ecosystem stability and have a wide geographical distribution and high phylogenetic value. A considerable number of the dendrocollection plants belong to species listed in the Red Data Book of the Republic of Azerbaijan. These species have high agrobiological characteristics and are important for ecological monitoring and breeding programmes. The collection predominantly consists of fruit plants bearing pome, stone and nut fruits, which are distinguished by their high adaptive and productive capacities.

Consequently, the taxonomic representativeness of the flora in the Gene Pool Garden can be considered high. This finding highlights the garden's scientific and strategic importance in conserving regional biodiversity, ensuring sustainable ecosystem management and enriching the country's agrobiodiversity. The research results confirm that the Gene Pool Garden serves as a centre for preserving biological diversity and as a potential basis for applying ecological and agrarian innovations.

CONCLUSIONS

1) The study of the inventoried biodiversity of the Gene Pool Garden identified 11 main geobotanical areas within its structural biodiversity framework. The ecological and cenotic composition of the flora was analysed at family, genus and species levels, and the number of species and individuals of each plant taxon was determined. Based on the research conducted, a schematic map of the

garden was created to visualise the spatial distribution of biodiversity. The dendrocollection of the Gene Pool Garden was found to preserve 807 individual fruit-bearing plants belonging to 124 species across 11 families. The Gene Pool Garden's structural biodiversity is simple and belongs to the conserved association type. The successional state of the geobotanical plots corresponding to the individual plant successions is generally satisfactory.

2) The α and γ diversity indices of the species in the gene pool garden suggest that the density of existing plant species ranges from 0.76 to 11.8, with species richness varying from 1 to 37. The highest density of species was recorded in the eleventh geobotanical area (Collection Garden), while the greatest richness of species was observed in the second area (Pear Garden). These results suggest that the phytocoenotic structures of different sections of the garden depend on ecological conditions, soil-climatic factors and the degree of anthropogenic impact.
3) Analysis of the taxonomic diversity revealed that the Gene Pool Garden is home to a wide variety of pomaceous, drupaceous and nut-bearing plant species that are widely used in the food and pharmaceutical industries, as well as forming part of the population's daily diet. This confirms the garden's high scientific and practical value.

Overall, the successional state of the geobotanical areas representing various stages of plant succession in the Gene Pool Garden was deemed satisfactory. This suggests that favourable ecological conditions have been established to ensure the stability of existing ecosystems and the long-term preservation of biodiversity.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to this study.

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ORCIDS:

Farhad Azizov:	https://orcid.org/0000-0002-9438-066X
Aygun Ismayilova:	https://orcid.org/0009-0002-0924-9323
Aygun Babazade:	https://orcid.org/0009-0000-5343-7773
Mubariz Pashayev:	https://orcid.org/0009-0004-1793-0789
